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(54) Humidifiers for inhalers

(57) The apparatus incorporates a temperature control arrangement by which air drawn through the apparatus is supplied in a heated, moist condition at or close to a critical temperature of 43°C.

The apparatus comprises a water chamber 6, heating means 11 for the water, means (preferably a fan 4) for drawing air over the water to an outlet 8, a face mask 15 for the outlet, and a temperature sensor 13 within the outlet adapted to control either the heating means and hence the water temperature, or the speed at which the air is drawn over the water, or both, to maintain the air at or close to a required elevated temperature.

Preferably, the apparatus is designed to deliver air to the face mask 15 in a volume substantially greater than that required for breathing, and the face mask covers the nose and mouth of the user and is formed with vents 23 through which excess air together with air exhaled by the user can pass to atmosphere.

FIG. 1

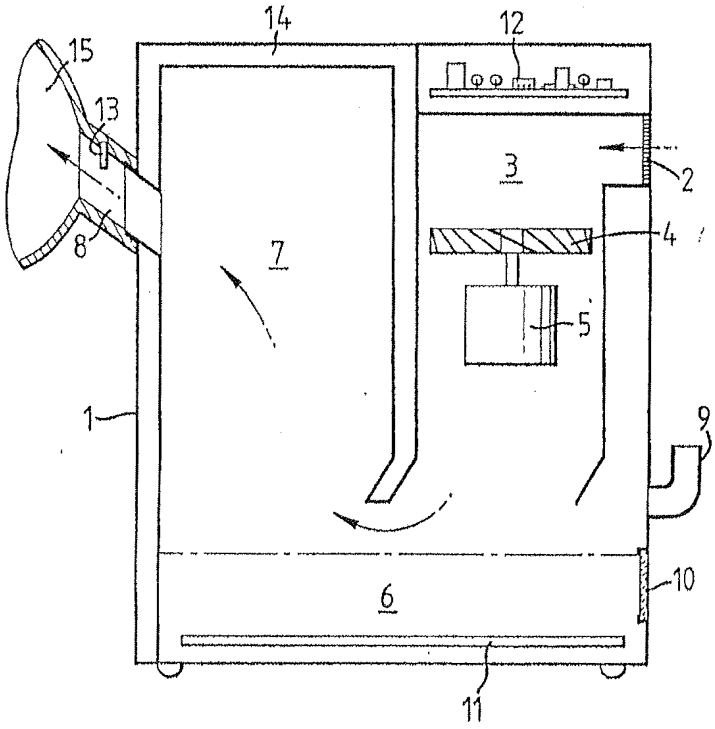

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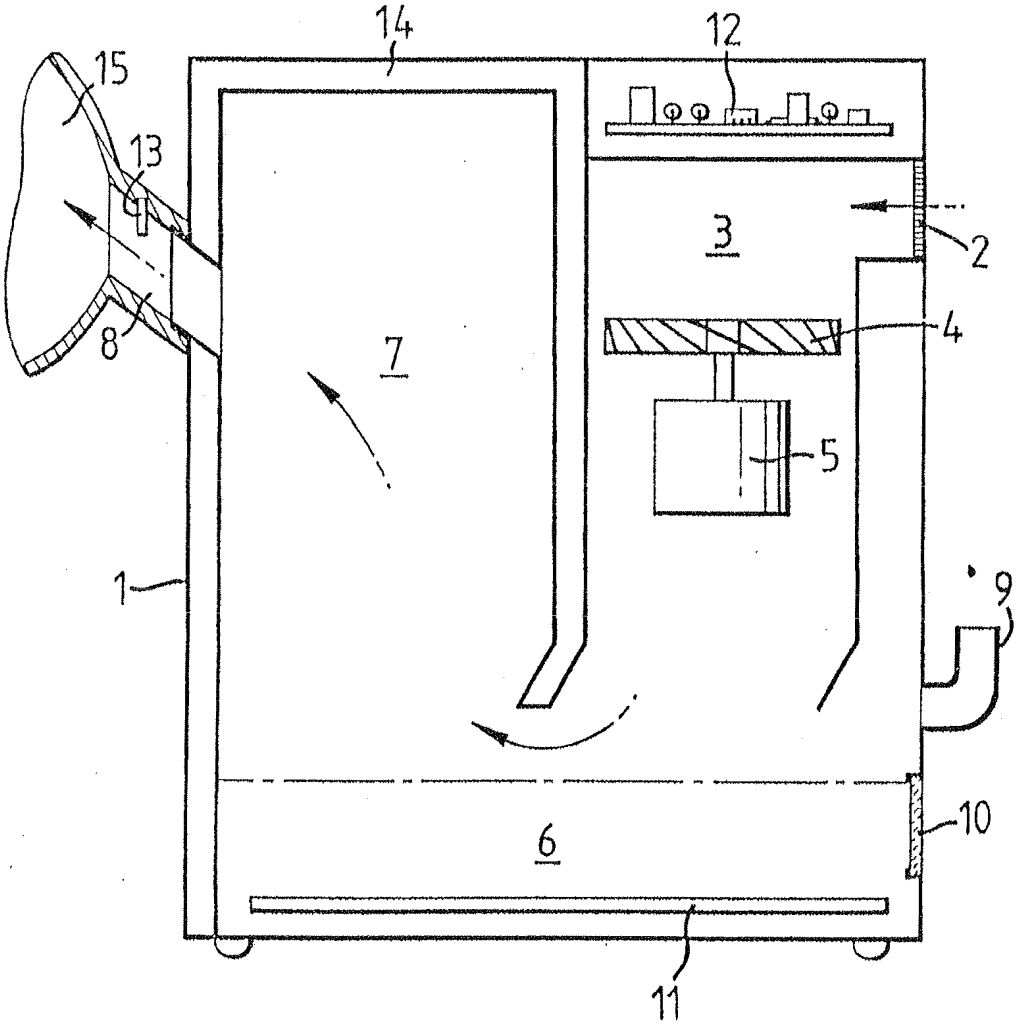
FIG.1



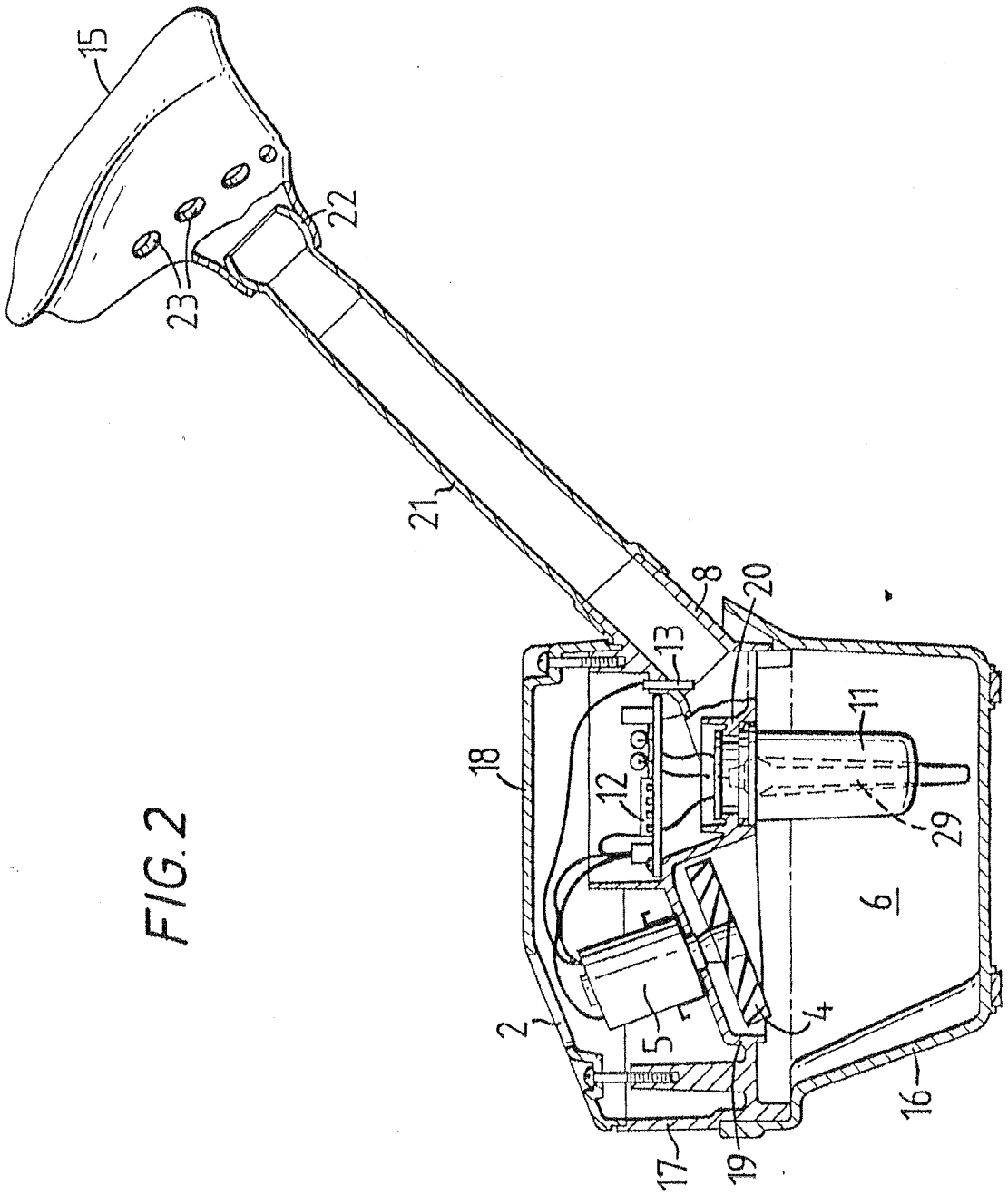


FIG.2

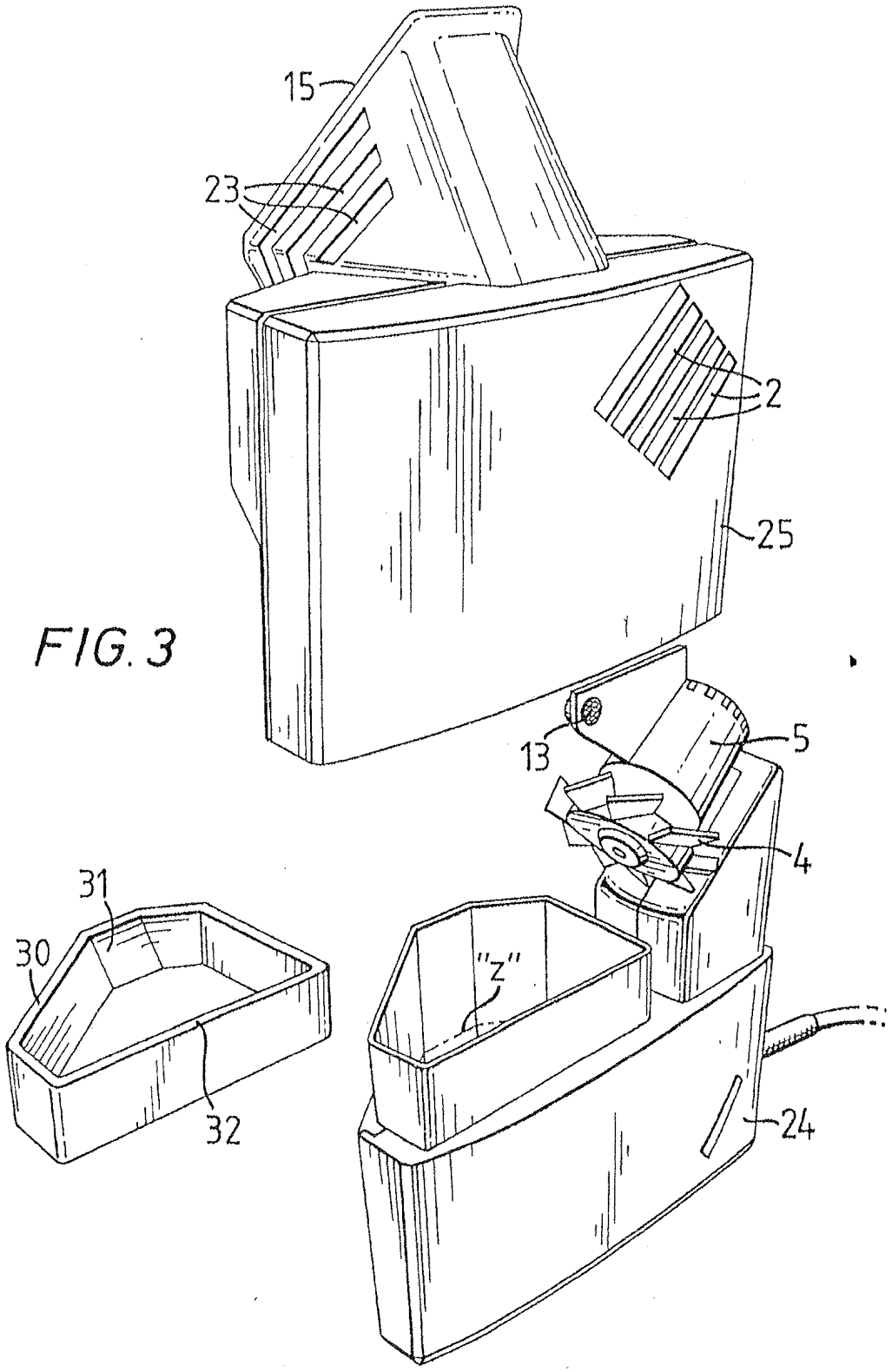
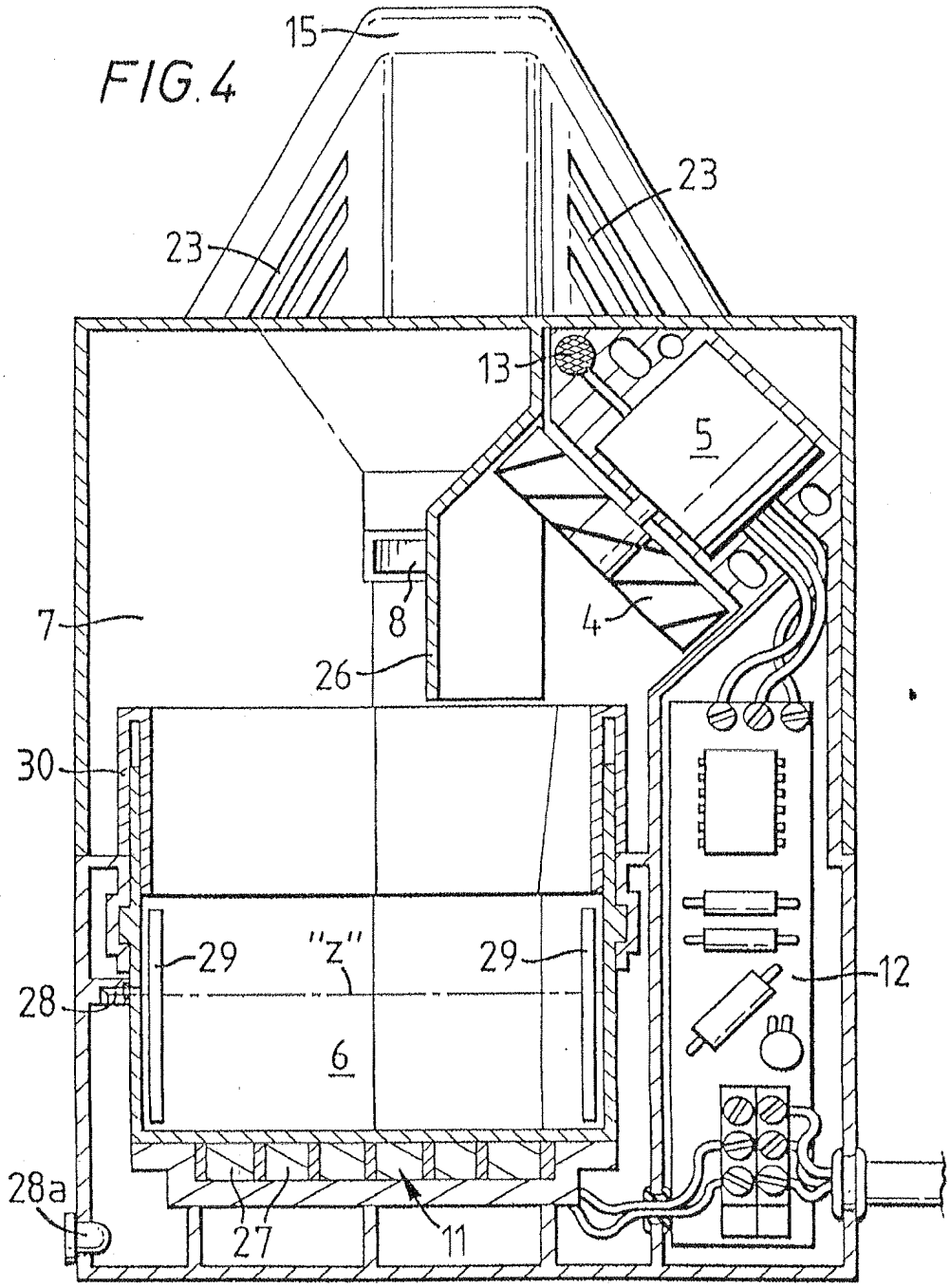


FIG. 3

FIG.4



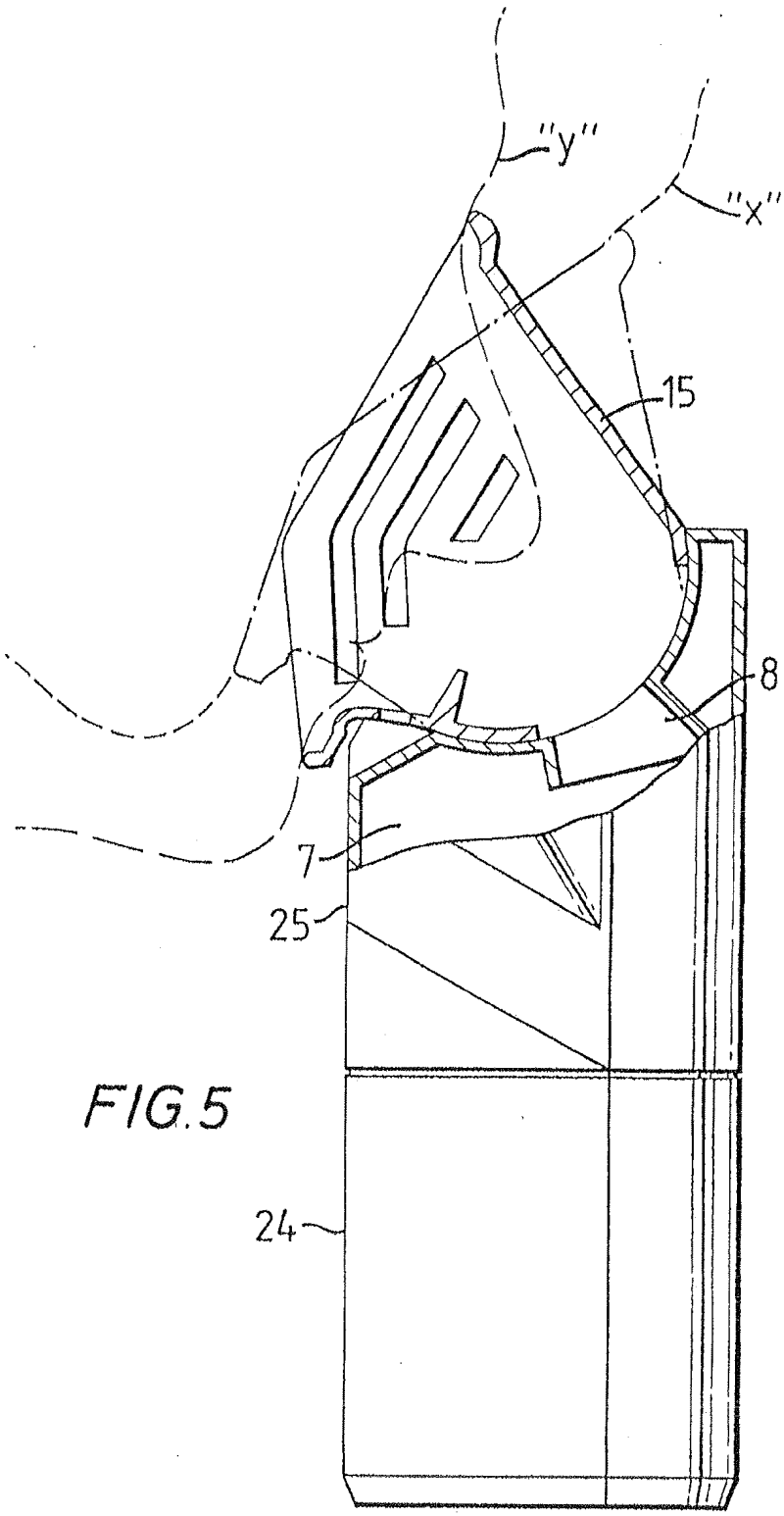
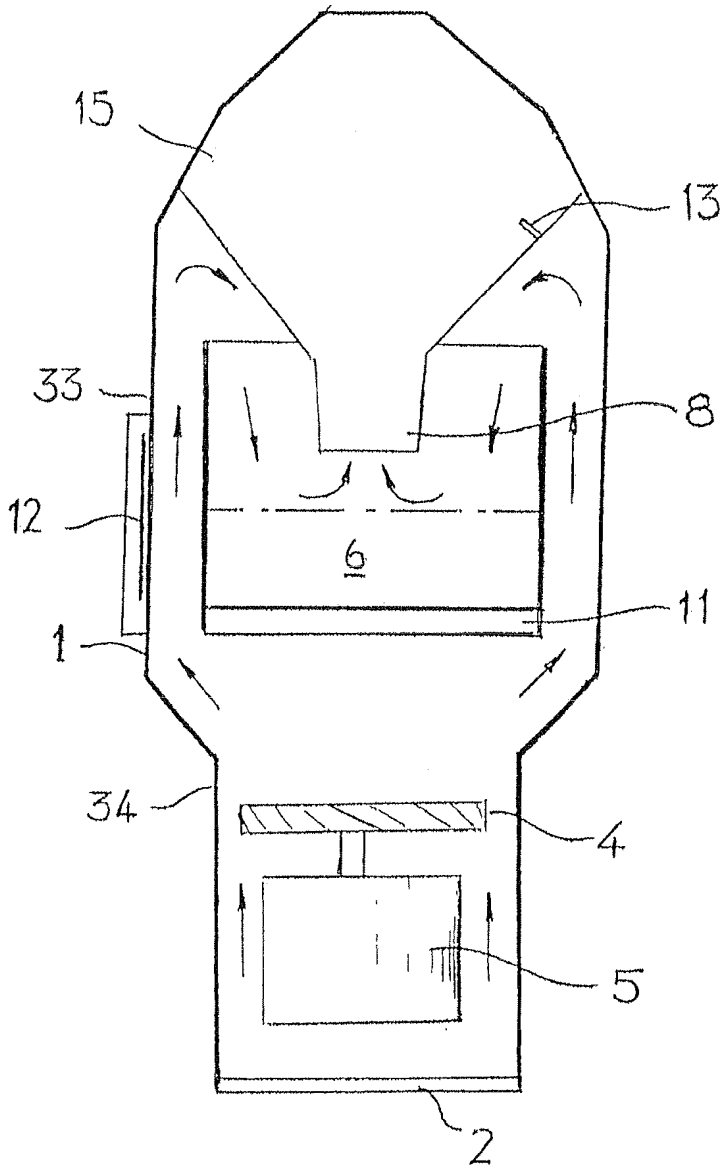


FIG.5

FIG 6



SPECIFICATION

Medical breathing apparatus

This invention relates to breathing apparatus for medical purposes.

It has been found that humid air at around 90% relative humidity and a critical temperature of 43°C, when breathed by a patient for periods up to around 20 minutes, is effective in rendering groups of viruses in the upper respiratory tract inactive, which results in the body being able to counteract colds, allergies, etc efficiently, and thereby reduce dramatically the patient's recovery time.

Although breathing apparatus has been proposed for such treatment, the arrangement of the apparatus, particularly the temperature control, has not been well designed. Hence, the temperature of the heated, moist air has varied widely from the critical temperature, thereby reducing the effectiveness of the apparatus.

An object of the invention is to provide breathing apparatus incorporating an efficient temperature control arrangement by which air drawn through the apparatus is supplied to the user – in a heated, moist condition at or close to the critical temperature.

According to this invention such breathing apparatus is characterised by a water chamber, heating means for the water, means for drawing air over the water to an outlet, a face mask for the outlet, and temperature sensor means located at or adjacent said outlet adapted to control either the heating means and hence the water temperature, or the speed at which the air is drawn over the water, or both, to maintain the air at or close to a required elevated temperature.

Preferably, the apparatus is designed to deliver air to the face mask in a volume substantially greater than that required for breathing, and the face mask is formed with vents through which excess air together with air exhaled by the user can pass to atmosphere.

Preferably the means for drawing air is a fan driven by an electric motor, which may be powered by the mains or a battery.

Conveniently, the heating means is either an electrical resistance, or positive temperature co-efficient (PTC) elements and is controlled by the temperature sensor, and temperature adjustment is effected via an electrical control circuit, e.g. a solid state circuit, designed to regulate the power supplied to said heating means and/or to the fan motor.

In order that the invention may be readily understood, four embodiments of breathing apparatus in accordance therewith will now be described, with reference to the accompanying drawings in which:-

Figures 1 and *2* are half-sectional views of the first and second embodiments, respectively,

Figure 3 is an exploded perspective view of the third embodiment,

Figure 4 is a part sectional rear view showing the interior of the third embodiment,

Figure 5 is a part sectional side view of the third embodiment, and

Figure 6 is a part sectional side view of the fourth embodiment.

Referring to Figure 1, in this embodiment the apparatus is free-standing and comprises a rectangular housing 1 which may be moulded from plastics material, eg ABS. The housing has an air inlet opening 2 leading to an inlet chamber 3 in which a fan 4 driven by a motor 5 is located, a water chamber 6 in the lower part of the housing, and a mixing chamber 7 leading to an outlet 8 which is preferably a flexible pipe to which a face mask 15 can be removably fitted.

The water chamber 6 is filled with water via a filler 9 and has an associated sight glass 10 to indicate the level of water therein. An electric resistance heating element 11 is located within the water chamber 6 and power is fed thereto from the mains or a battery, in a regulated manner, via an electric control circuit, e.g. a solid-state printed circuit 12, in response to a temperature sensor probe 13 located in the outlet 8. The mixing chamber 7 is insulated, in this embodiment by a surrounding sealed cavity wall 14 which provides an air pocket, so that the temperature in the mixing chamber is substantially unaffected by external changes in temperature.

In use, ambient air is drawn into the inlet chamber via the fan 4 and is guided downwardly towards the water surface, where it passes along said surface to abstract heat and water droplets therefrom, thereby to heat and humidify the air. The heated, humid air then flows upwardly to collect in the mixing chamber 7 from where it is supplied, in use, to the face mask 15.

The temperature and, if required, the humidity of the air passing through the outlet 8 is sensed by an appropriate device, such as the temperature probe 13, and if the air is found to be outside a required range, e.g. a temperature range between 40 - 45°C, it initiates the control circuit 12 to regulate the power supplied to the heating element 11 and, if desired, to the fan motor 5 so as to adjust appropriately the temperature of the water and possibly the air flow speed.

For electrical safety, and prevention of corrosion, the fan motor 5 is preferably encapsulated and operates at a low DC voltage. The circuit board 12 is also encapsulated for safety and reliability of operation in humid conditions. For additional safety, the apparatus can be powered from an external A.C. or D.C. voltage supply using a double isolation transformer.

As mentioned hereinbefore, it is preferable to limit use of the apparatus to periods up to approximately 20 mins, for which an appropriate timing/alarm mechanism could conveniently be built into the apparatus.

Referring to Figure 2, the second embodiment shown therein is also free standing and like parts have been given the same reference numerals.

In this embodiment, the housing 1 is in three parts, preferably moulded from a plastics material such as ABS, and comprises a one part base 16, which incorporates the water chamber 6, and a two part cover 17, 18. The lower cover part 17 has a shaped wall 19 which carries most of the associated equipment, including the fan 4 and motor 5, the heating element 11, and circuit board 12.

The motor 5 is mounted on a sloping part of the wall 19 immediately beneath the inlet opening 2,

which is formed in the top cover part 18. The fan 4 is coupled to the motor beneath the wall 19 and draws air through openings in said wall and directs it across the surface of the water in chamber 6 towards the outlet 8, which is formed in the lower cover part 17.

The heating element 11 in this embodiment is of the electric resistance type and has an aluminium shell which is encased within a coating of PTFE to prevent oxidation of the casing and to facilitate cleaning. The element is located vertically beneath the wall 19 and is mounted at its upper end within a boss 20 formed in said wall with its terminal above the latter.

The circuit board 12, which is preferably encapsulated for safety and reliability of operation, is mounted directly above the heating element 20 and is appropriately connected to the associated equipment, including the temperature sensor 13 located within the outlet 8. The apparatus can be conveniently sited on a worktop, or floor, and the height of the face mask 15, which is designed to fit over the nose and mouth of the user, can be adjusted by one, or more, or even a telescopic extension tube 21, which is connected to the face mask via a ball joint 22 so that the mask can be pivoted and/or rotated to a comfortable position for the user.

It will be noted that the arrangement of the equipment, and in particular the heating element, is such that all electrical connections are well above the fill level of the chamber 6, and indeed are separated therefrom by the wall 19, thereby enhancing safety.

A pair of supports are provided in the base part 16, one (not shown) in front of, and one 23 to the rear of, the heating element 11 as seen in the drawing. These supports ensure that the lower part of the heating element 11 is not damaged when the cover part 17 is removed and laid upon a work surface for cleaning or service. Conveniently, at least one of the supports incorporates a water probe over its height which, by means of an electrical connection via the circuit board 12, indicates the level of water in the chamber 6.

It will be noted that the two part cover 17, 18 can be lifted clear of the base part 16 to provide ready access to the chamber 6 for filling, whilst access to the associated equipment for repair of servicing is obtained by removing the top cover part 18.

The apparatus is designed to produce an air speed of approximately 5 metres/sec across the water surface, and to retain the critical temperature of the air, the water is maintained substantially constant at an appropriate temperature depending upon the fill volume and ambient conditions, eg between 65 to 75°C. Thus, moist air is produced at or close to the critical temperature of 43°C, which is delivered at a pressure above atmospheric to the face mask (15), in a volume of approximately 40 litres/min. This volume is, of course, far in excess of that required by the user and, hence, vents 22 are provided in the mask so that the excess air, together with the air exhaled by the user, can vent to atmosphere. This is important since, when air at 43°C is inhaled it is cooled substantially, perhaps to around 37°C, due to vascular cooling in the bronchil. This reduced temperature, when exhaled, could otherwise affect the constancy of the temperature of the heated, moist air being produced by the apparatus. It will be appreciated that, by providing a mask 15 which covers the nose and mouth, the heated, moist air not inhaled and venting to atmosphere nevertheless acts to warm the outside of the nose and mouth and, therefore, ensures the minimum of heat dissipation around this area.

Referring to Figures 3 to 5 the third embodiment is portable and like parts are again given the same reference numerals.

In this embodiment the housing is in two parts comprising a base 24 and a cover 25.

The base 24 incorporates the water chamber 6, and most of the associated equipment including the fan 4 which is inclined to direct air towards the chamber 6, motor 5, heating element 11, and circuit board 12. The cover 25 incorporates a baffle wall 26 to guide air from the fan towards and over the water surface in the chamber 6 into the mixing area 7 and outlet 8 to the face mask 15.

As shown in Figures 3 to 5, the apparatus is provided with a wedge shaped front wall to provide stability when placed upright on a worktop. In this position, the user would tend to press his mouth and nose down into the face mask 15 as shown in dashed outline "x" in Figure 5. However, in most cases, the user would probably press the face mask manually against his nose and mouth and perhaps strap it in place. For this, it would be more comfortable for the user to adopt the position shown in dotted outline "y". To cater for these different user positions, the face mask 15 is pivotally mounted to the top of the cover 25 so that it can rotate from the position shown in solid lines in Figure 5 to the position shown chain dotted.

Referring again to Figure 4, in more detail, the heating element 11 comprises a number of positive temperature co-efficient (PTC) elements 27 spaced across the bottom wall of the chamber 6 which are regulated to operate at a working temperature which will maintain the water at an appropriate temperature, eg approximately 80°C, depending upon the normal fill volume of water used in the chamber 6 and ambient conditions. The fill level line "z" for the apparatus is controlled by an overflow pipe 28 which can drain into the sealed air space provided around the chamber 6 for insulation. This water can be subsequently removed via a drain plug 28a. Because of the relatively high temperature required for the heating element, safety is extremely important, and PTC elements are especially advantageous since they are inherently safe against overheating. However, if a conventional electrical resistance element such as described for the first and second embodiments is used, a thermal cut-out would be included in the heating element to prevent overheating. In either case a thermal cut-out could be used in the circuit board 12 for additional safety.

The circuit board 12 is solid state and preferably encapsulated for reliability of operation. It would be designed to include the following control features:-

a) a water level sensing circuit including water sensing probes 29,

b) a temperature control sub-circuit, for con-

trolling the temperature of the heating element 11, and hence the water temperature, in dependence upon the water level sensed, and/or for adjusting the fan speed, and hence the air flow over the water surface. This control circuit is preferably in the form of a proportional band, zero voltage switch for providing pulsed or continuous voltage to the heating element so as to provide accurate control and to reduce the possibility of electrical interference in use.

c) a comparator sub-circuit for comparing the output resistance from the sensor 13, which is preferably a thermistor with a basic pre-set value, this sub-circuit being connected to the temperature control sub-circuit for providing a correcting signal for finely adjusting the water temperature, or fan speed.

d) a mercury tilt switch connected so as to cut-off power to the heating element 11 if the apparatus moves beyond a predetermined angle from its upright position so as to ensure electrical safety.

To reduce to a minimum the possibility of scalding the user should the apparatus fall over, an anti-spill cover 30 (see Figure 3) is provided for the water chamber 6 having sloping front and rear side walls 31, 32 to act as a dam to retain the water.

Referring to Figure 6, this embodiment is also of a convenient design to be portable. It comprises an elongate tubular housing 1 which, in use, is orientated to be generally upright. The housing comprises an upper end portion 33 and a lower end portion 34 of smaller dimensions, enabling it to be conveniently held by the hands of the user. The motor 5 is supported centrally within the portion 34, to leave an air passage around it (as shown), above the air inlet opening 2, which is defined by the bottom of the casing 1. The fan 4 is mounted above the motor near the junction between the portions 33 and 34. The water chamber 6 is supported centrally within the portion 33 to leave an air passage around it (as shown), the water chamber having a suitable heating element 11 associated therewith. A face mask 15 is mounted on the top of the portion 33, which would be generally as described above with reference to the third embodiment, and the temperature sensor 13 is appropriately located therein. The circuit board 17 is mounted in a convenient position, e.g. as shown.

In use, as shown by the arrows, air is drawn upwardly through the opening 2 and through the air passages around the motor 5 and tank 6, whereafter it is deflected by sloping walls 34 defining the face mask 15 across the water in the tank 6 and then upwardly through an outlet 8 to pass into and through the face mask. As described in respect of the foregoing embodiments, the heated, moist, air delivered to the face mask 15 is in a volume far greater than body requirements and the excess air would be vented to atmosphere.

CLAIMS

1. Breathing apparatus incorporating a temperature control arrangement by which air drawn through the apparatus is supplied in a heated moist condition, characterised by a water chamber, heating means for the water, means for drawing air over the water to an outlet, a face mask for the outlet, and temperature sensor means located at or adjacent said outlet adapted to control either the heating means and hence the water temperature, or the speed at which the air is drawn over the water, or both, to maintain the air at or close to a required elevated temperature.

2. Breathing apparatus according to Claim 1, characterised in that said apparatus is designed to deliver air to the face mask in a volume substantially greater than that required for breathing, and in that the face mask is formed with vents through which excess air together with air exhaled by the user can pass to atmosphere.

3. Breathing apparatus according to Claim 1 or 2, characterised in that the means for drawing air over the water delivers said air to the outlet at a pressure above atmospheric.

4. Breathing apparatus according to any one of Claims 1 to 3, characterised in that the face mask is designed to cover the nose and mouth of the user.

5. Breathing apparatus according to any one of Claims 1 to 4, characterised in that the means for drawing air is a fan driven by an electric motor.

6. Breathing apparatus according to any one of Claims 1 to 5, characterised in that the heating means is either an electrical resistance, or positive temperature co-efficient (PTC) elements, in that the heating element is controlled by the temperature sensor, and in that temperature adjustment is effected via an electrical control circuit, designed to regulate the power supplied to said heating means and or to the fan motor.

7. Breathing apparatus according to Claim 6, characterised in that the electrical control circuit includes a temperature control sub-circuit for controlling the temperature of the heating element in dependence upon the water level sensed, and/or for adjusting the fan speed, and a comparator sub-circuit for comparing the output from the temperature sensor with a pre-set valve and providing a correcting signal to the temperature control sub-circuit for finely adjusting the water temperature, of fan speed.

8. Breathing apparatus according to any one of Claims 1 to 7, and which is designed to be portable, characterised in that the face mask is pivotally mounted to the outlet to enable the user to tilt the mask in relation to the body of the apparatus into a comfortable position.

9. Breathing apparatus according to any one of Claims 1 or 8, and which is designed to be portable, characterised in that the water chamber is provided with an anti-spill cover having sloping walls which act as a dam to prevent egress of water should the apparatus fall over.

10. Breathing apparatus according to Claim 9 characterised in that the electrical circuit includes a tilt switch connected to cut-off power to said heating element if the apparatus moves beyond a predetermined angle from its upright position.

11. Breathing apparatus according to any one of Claims 1 to 5, characterised in that the housing is of elongate tubular form and is intended to be used in a generally upright condition with the air inlet opening at the bottom and the face mask at the top of the

housing, in that the motor, fan and water tank are located at spaced positions within the housing to leave air passages through the housing, and in that air is drawn through the length of the housing and deflected over the water in the water tank before passing through an outlet into the face mask.

12. Breathing apparatus constructed, arranged and adapted for use substantially as hereinbefore described with reference to, and as shown in, Figure 1, 2, 3 to 5 or 6 of the accompanying drawings.

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